MANITOBA CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

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CREDA

Canada

MANITOBA

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WINNIPEG, MANITOBA

LOW ENERGY HOUSING

CHIMO
— STEINBACH, MANITOBA —

15 (81-72)

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MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program has a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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1. SUMMARY

The Neufeld Residence was surveyed on June 2, 1982, in the presence of the builder and the homeowner. The features of the home were pointed out by the builder, who emphasized wall construction, orientation on lot and aesthetics.

Construction of the home began in the Fall of 1981 and was completed in the Spring of 1982. The house has been occupied by the Owner since the second week of May, 1982.

Prior to the construction of the home, the National Research Council of Canada in Saskatoon was consulted, a computer analysis (Appendix A) made, and recommendations made to improve the techniques used in the design.

During the construction of the home an air leakage test was performed using the infiltrometer (Appendix B).

Major objectives of the builder were as follows:

.1 Make full and efficient use of energy by conservation techniques.

.2 Construct a wall with a thickness capable of accommodating R-48 (14") glassfibre batts without constructing two separate walls and to achieve this with less cost.

.3 Locate the house on the lot so that major fenestration area would be on a southern exposure.

.4 Provide a continuous path of insulation from the wall section into the attic area.

.5 Provide level attic insulation to the exterior of the perimeter wall by utilizing a raised heel type roof truss.

.6 Design the roof truss/wall intersection so that it looks proportionally correct, and aesthetically appealing when compared with conventional housing.

.7 Demonstrate the effectiveness of using an air-to-air heat exchanger and circulating hot water duct heater instead of other types of heating systems.

.8 Provide a model and demonstration for contractors and the general public of the advantages of the techniques employed.

.9 To attract greater public attention to the need for alternate energy sources and to the new or revised technologies to be considered in building construction.

It is the opinion of the reporters that the majority of the objectives of the builder have been met in the design and construction of this home.

The I-beam stud walls use less material and are lighter, stronger and easier to erect than conventional double stud walls. The major disadvantage of the design is that vapour barrier installation is more involved and labour intensive.

The circulating hot water duct heater, combined with an air-to-air heat exchanger is recommended as a heating system for low energy homes.

Assuming the public and other contractors are made aware of this project, the reporters would expect positive fulfillment of all listed objectives.

2. Résumé

La résidence des Neufeld fut examinée le 2 juin 1982 en présence de l'entrepreneur et du propriétaire. Les caractéristiques de la maison furent décrites par l'entrepreneur qui fit valoir la construction des murs, l'orientation du terrain et le côté esthétique.

La construction de la maison commença en automne 1981 et se termina au printemps 1982. La maison est occupée par le propriétaire depuis la deuxième semaine de mai 1982.

Avant que la maison ne fut construite, on consulta le Conseil national de Recherches Canada à Saskatoon; il en résulta une analyse à l'ordinateur (Appendice A) et des recommandations pour améliorer les techniques employées.

Au cours de la construction de la maison, on fit un test d'infiltration d'air en se servant d'un infiltromètre (Appendice B).

Les principaux objectifs de l'entrepreneur étaient les suivants:

.1 Utiliser l'énergie intégralement et efficacement grâce aux techniques sur la conservation de l'énergie.

.2 Construire un mur assez épais pour contenir deux fuseaux R48 (de 14 pouces) en fibres de verre sans devoir construire deux murs séparés. Arriver aussi à faire cela à un coût réduit.

.3 Situer la maison sur le terrain de façon à ce que les fenêtres soient tournées en majeure partie vers le sud.

.4 Créer une zone d'isolation continue entre le mur et le grenier.

.5 Assurer l'isolation au même niveau entre le grenier et le mur périphérique extérieur en se servant d'un assemblage de toiture à supports élevés.

.6 Dessiner l'intersection de l'assemblage de la toiture et du mur de façon à ce que les proportions paraissent justes et que le côté esthétique soit agréable par rapport aux maisons ordinaires.

.7 Démontrer l'efficacité des échangeurs thermiques air-air et des systèmes de chauffage avec conduits à circulation d'eau chaude par comparaison aux autres systèmes de chauffage.

.8 Donner aux entrepreneurs et au public en général un modèle et un moyen de démonstration qui fassent ressortir les avantages des techniques employées.

.9 Attirer l'attention du grand public sur les besoins d'énergie de remplacement et sur les technologies nouvelles ou révisées qu'il faut envisager dans la construction des bâtiments.

Les rédacteurs de ce rapport croient que la plupart des buts visés par l'entrepreneur ont été atteints dans le domaine de l'agencement et de la construction de cette maison. Les murs à poutres en double T sont plus légers et plus faciles à ériger que les murs ordinaires à montants jumelés. Le grand désavantage de ce genre de construction, c'est que l'installation du pare-vapeur est plus compliquée et demande plus de travail.

Combinés aux échangeurs thermiques air-air, les systèmes de chauffage avec conduits à circulation d'eau chaude sont recommandés comme systèmes de chauffage des maisons à faible consommation énergétique.

Si le public et les autres entrepreneurs sont tenus au courant de ce projet, les rédacteurs de ce rapport s'attendent à ce que tous les objectifs ci-dessus soient atteints de façon positive.

2. SCOPE OF WORK AND BUILDING LOCATION

.1 Scope of Work

We were contracted to evaluate the construction techniques used in the Neufeld Residence in Steinbach.

Our efforts were to concentrate on features that may make this residence unique when compared with conventional construction standards, as it relates to energy conservation. These areas include wall construction, insulation levels, roof trusses, air tightness levels and general construction techniques.

Specifically our evaluation was to consist of:

.1 Visiting the site and discussing building features with the Owner.

.2 Obtaining all available literature on this building from the Owner.

.3 Evaluation of building construction based on information 1. and 2.

.4 Preparation of final report, consisting of the following:

.1 The results of our observations and evaluation.

.2 Comparative data for this home and other energy efficient homes being built at present.

.3 As a result of .1 and .2, our opinion, (with necessary qualifying information) as to whether or not the unique features of this building can be effectively utilized in Manitoba's housing industry.

.2 Location and Map

Steinbach is located approximately 40 miles South East of Winnipeg on PTH #12. Figure 1 shows the location of No. 6 Sherwood Place (Neufeld Residence) in Steinbach.

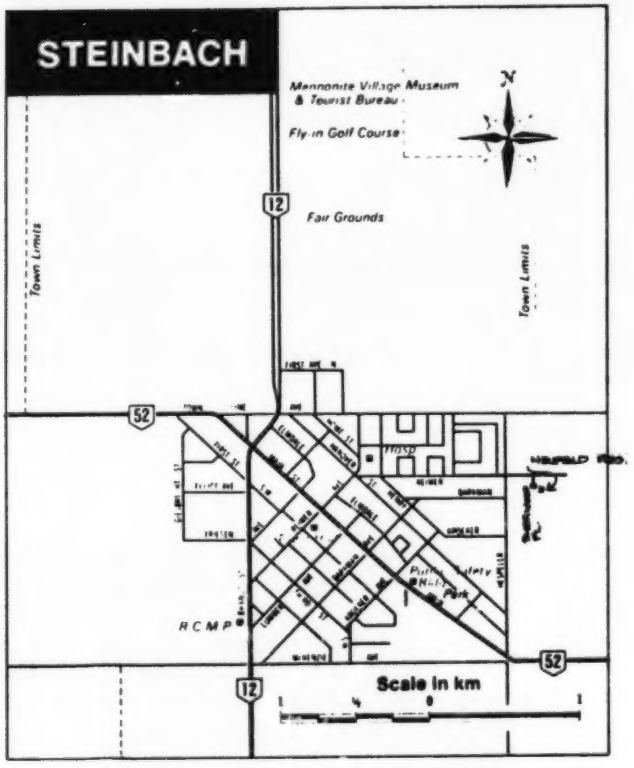

STEINBACH
Mennonite Village Museum
& Tourist Bureau
Fly-in Golf Course
Fair Grounds
Town Limits
Town Limits
N
12
52
RCMP
Scale in km

FIGURE 1

3. BUILDING DESCRIPTION

.1 General Building Description

The Neufeld Residence in Steinbach is a bungalow style low energy house with a full basement utilizing features to conserve energy. The home, designed and built by Chimo Lumber in Steinbach, displays unique construction features not found in most other types of residential construction today. Refer to Floor Plan in Appendix G.

.2 Building Areas

Component		Area (m^2)
Ceiling		123.79
Walls (net)		100.09
Basement wall above grade		14.87
Basement wall below grade		118.96
Doors		5.58
Windows:	North	1.08
	South	6.84
	East	1.37
	West	3.46
Basement Floor		123.79

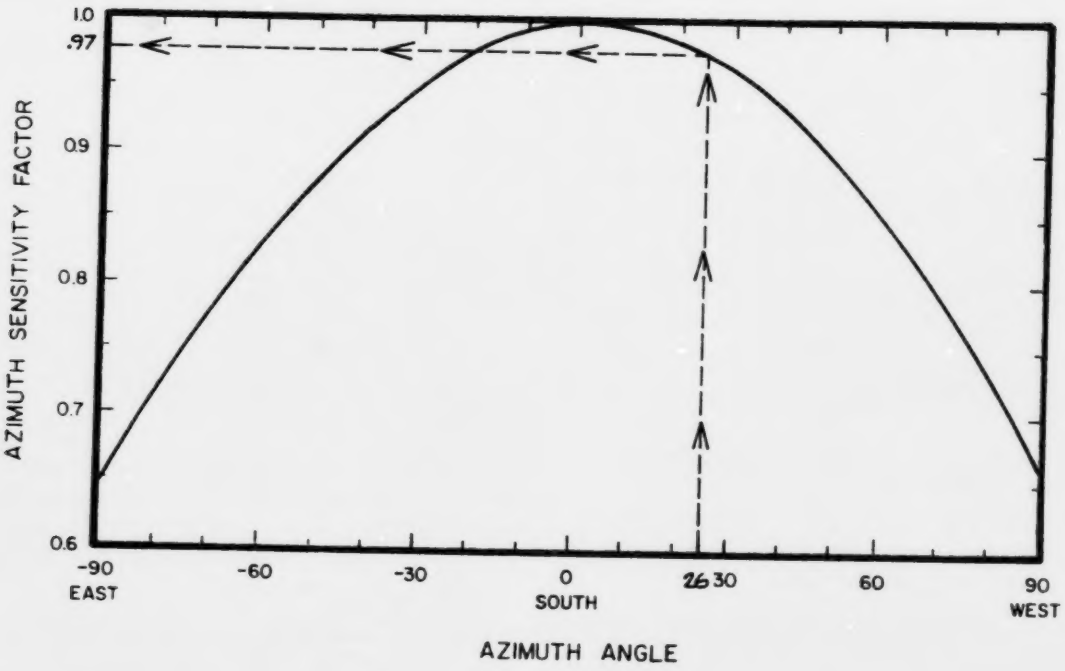
.3 Windows

All windows are triple glazed, manufactured by Loewen of Steinbach. See insert attached. Most windows are openable (either casement or awning). Unfortunately these windows have not proven to be air tight in the past. This was also confirmed by the builder in the Neufeld Residence.

Window sections are well distributed with 52% of all the glazed surface located on the south. The North, East and West sides attribute 8%, 10% and 30% respectively. Note that the least amount of glazing is on the North side.

In Appendix D Site Plan, the location of the windows are indicated as well as the deviation from South, which is approximately 26 degrees West. By examining Figure 2, it can be noted that there is only a 3% reduction in thermal performance of the windows because of the deviation from true South.

The windows are located on the inside of the double wall, flush with the interior finish, with the sill located on the outside.



Reduction in thermal performance for azimuth angles deviating from true south (0°).

FIGURE 2

.4 Roof Trusses

The type of roof trusses used are now common in low energy housing. These trusses are commercially manufactured and said to have a 'raised heel' (Figure 3) which allows the attic insulation to be blown to the required thickness right to the exterior of the 14" perimeter wall. In this case cellulose fibre insulation was used and installed to a level of an R-60 value.

A unique feature of the truss used on the Neufeld home is the pitch and soffit width. The pitch has been increased to a 5/12 pitch rather than the usual 4/12 along with a soffit that is 3'-0" wide from fascia to wall. This gives the house the proportionally correct appearance when compared with conventional housing. Another advantage of the 3'-0" overhang is that it will shade the windows from the high summer sun, yet allow the low winter sun complete access.

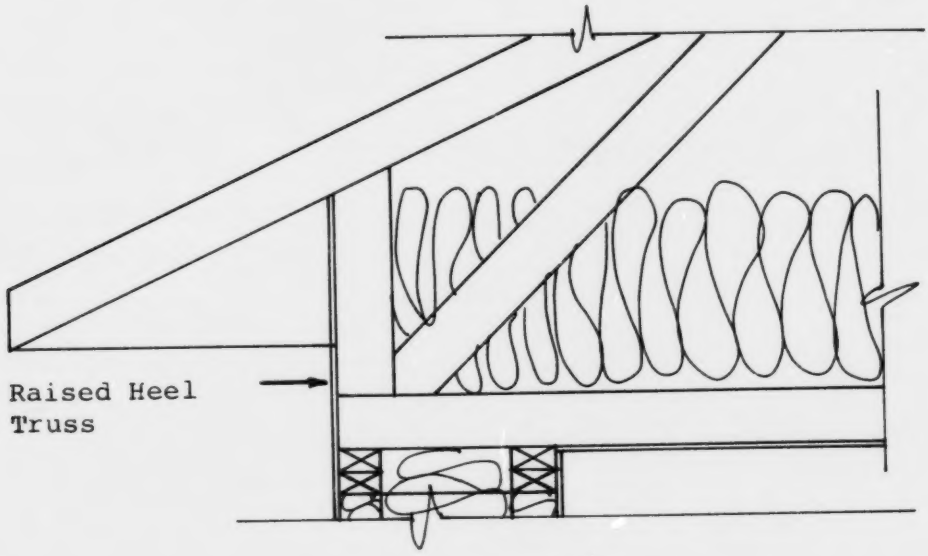


FIGURE 3

.5 Wall Framing

The wall framing is unique to the Neufeld Residence, manufactured by Chimo Lumber. The framing members are an 'I-Beam' type as shown in Figure 4. 2 - 2 x3's on end fastened together by a section of ¼" plywood. Current double wall construction is usually two walls built separately and then fastened together at the top and bottom by continuous plywood plates, also shown in Figure 4.

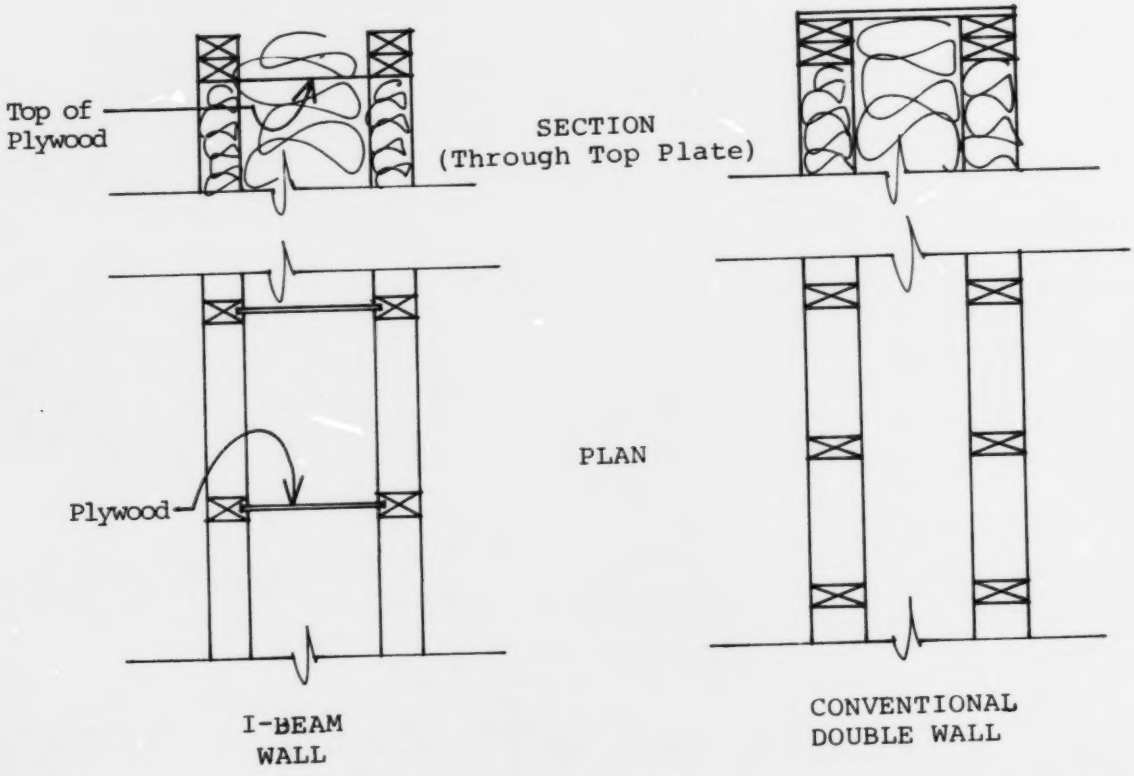


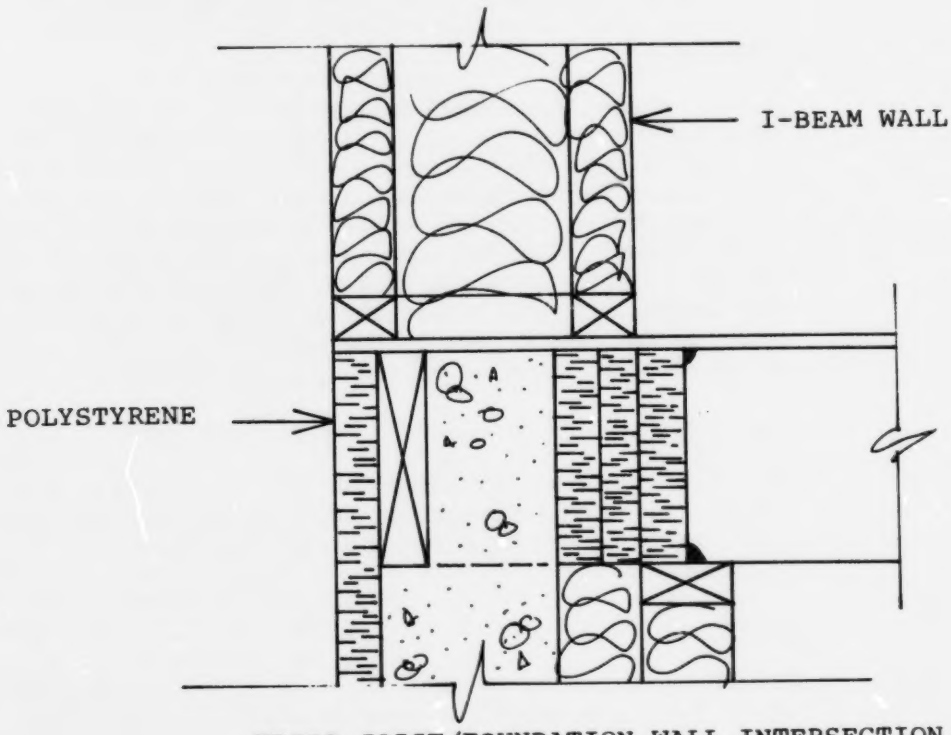
FIGURE 4

.6 Attic Ventilation

The reason for providing sufficent attic ventilation is to prevent the occurence of condensation/frost in the winter and heat build up in the summer. Frost occurs in the attic only because of warm moist air leaking into the attic and then condensing and freezing if not expelled by ventilation. The Neufeld Residence utilizes two large turbine type vents, along with continuous soffit venting.

.7 Floor Joist/Foundation Wall Intersection

As can been seen in Figure 5, the outside bottom plate of the "I-Beam" wall has been cantilevered over the edge of the floor joist header by 2". This cantilever was incorporated to accommodate the 2" of polystyrene that covers the exterior of the basement wall and floor joist header.



FLOOR JOIST/FOUNDATION WALL INTERSECTION

FIGURE 5

.8 Basement Wall

The basement or foundation wall is a poured-in-place 8" concrete wall. The wall has been insulated with 2 inches of polystyrene on the outside and framed and insulated with glass fibre batts on the inside for a total R-value of approximately 39.

.9 Basement Floor

The basement floor is 4" concrete poured over 4" of rigid polystyrene insulation.

.10 Heating

The type of heating system employed in the Neufeld home is a circulating hot water duct heater. 15' of 3/4" radiator fin cut into 6 sections and connected in series are located in a section of the ductwork directly above the 60 gallon (2-4500W) water heater. The water heater, used for domestic purposes as well as heating passes water through the coil via a bronze body pump. Located upstream from the coil is a 1000 cfm duct blower which moves household air over the coil and back into the living space. All hot water piping for domestic use and the heating system has been insulated with 1" glass fibre pipe insulation to cut down the heat loss from the pipes.

.11 Ventilation

As can be seen from Table 2, Appendix C, the Neufeld residence is a relatively tight house, i.e. it has a very low air change rate. Because of this the Neufelds would not experience dryness in their home common during Manitoba winters. This is because tight sealing does not permit cold, dry winter air to infiltrate into the house. It is probable that the home maybe too humid and stuffy. An air-to-air heat exchanger is a method of replacing this humid, stuffy air with fresh, dry outdoor air while recovering a good portion of the sensible and latent heat in the exhaust air. The heat exchanger used in the Neufeld house is a Lossnay VL-1500 (See Appendix E).

.12 Lighting

The majority of lighting for the home is provided by a mixture of natural lighting (through the large amount of south facing windows) and ceiling mounted fluorescent lighting, with only a small amount of incandescent lighting.

.13 Entrances

The Neufeld home has 3 exterior door locations, all of which utilize steel insulated doors for maximum insulation in an entry system. An addition feature is that each entry location is 'double protected' in one way or another to provide minimum air leakage. The rear door is located inside the garage for protection from wind, the front door opens into an 'air lock' type foyer and the patio exit is furnished with two steel insulated doors.

4. CONCLUSIONS AND RECOMMENDATIONS

A low energy house is one that minimizes energy requirements, and best utilizes them. This is almost always done by using large amounts of insulation by present standards, sealing the house to obtain as low on an air change rate as possible and reducing the glazing surfaces on all sides of the house except south, where it is commonly increased. The Neufeld residence is a home that seems to have taken advantage of all of these points. This is evident in Table 2, Appendix C, Air Leakage characteristics of Low Energy homes in the Winnipeg area, The Heat Loss calculations, Appendix A and the site plan, Appendix D.

Many of the construction and energy saving techniques used in the Neufeld residence can be utilized effectively in the housing industry in Manitoba. Conclusions relating to each feature of the home are presented below.

.1 Wall Framing

The I-Beam construction, in terms of material cost, is slightly lower than the conventional double wall construction. It is conceivable that conventional double wall construction could take the form of 2 x 3 construction, in which case the cost advantage of I-Beam construction may be eliminated.

The material costs for these two types of walls are almost identical.

82	-	I-Beam type studs @ 24" O.C. @ $5.50/stud	$451.00
240	-	2 x 4 studs @ 16" O.C. @ $1.45/stud	$348.00
6	-	4 x 8 sheets 1/2" plywood @ $13.95/sheet	$ 87.00
		TOTAL	$432.00

As previously outlined, the builder was concerned with providing a continuous path of insulation from the walls into the attic space. In the 'I-Beam' wall the two sides of the wall are held together by vertical strips of plywood. This leaves the top of the wall open to the attic instead of the continuous plywood top plate which blocks off this space in conventional double wall construction. The builders reasoning behind this was that if the insulation in the wall sagged the loose-fill attic insulation would fill any void. It would seem that the builder has undue concern in this area. Walls are usually built on the floor and then erected into place. This allows installers of insulation in both types of wall construction to do a proper job of installing glass fibre batts. As long as the batts are the proper size there is no danger of sagging.

The 'I-Beam' type wall is lighter than conventional double wall construction. The lighter wall has the advantage of requiring fewer men to erect it during construction.

The major draw-back to I-Beam wall construction is the installation of the air/vapour barrier on the inside of the inside wall (see Figure 6). Because the two walls are tied together by continuous plywood the air vapour barrier cannot be installed on the outside of the inside wall as in conventional double wall construction (also see Figure 6). The advantage of the installation on the outside of the inside wall is the fact that no penetrations for electrical service be made in the air/vapour barrier, yet there is no risk of condensation problems because the air/vapour barrier is located in a position where the temperature does not fall below the dew-point.

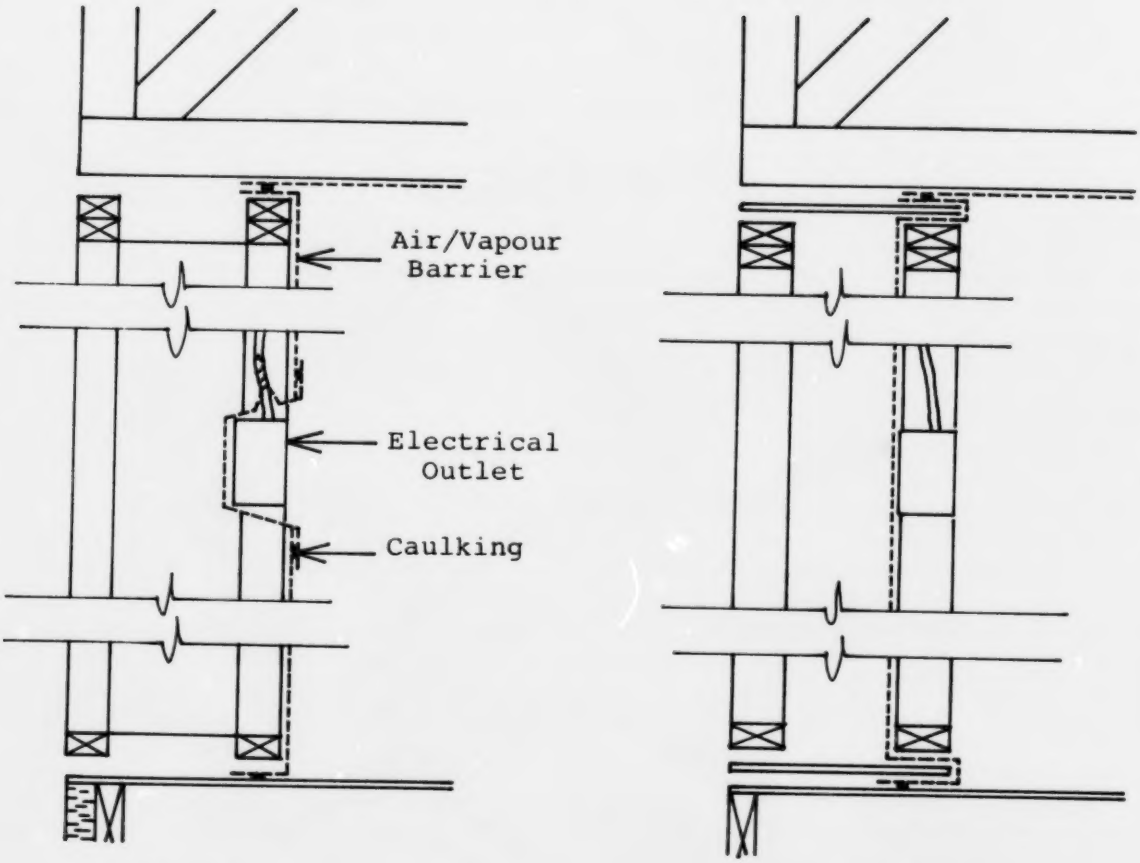

Air/Vapour
Barrier
Electrical
Outlet
Caulking
I-BEAM WALL
CONVENTIONAL WALL

FIGURE 6

In the case of the 'I-Beam' type wall all electrical services must penetrate the air/vapour barrier, hence require special attention to properly seal them. The labour costs for his may out weigh the additional labour cost of building the conventional double-wall. The builder attested that the outlets and switches did leak when the house was put under a negative pressure.

It is our opinion that the construction of the double wall with the air/vapour barrier on the outside of the inside is the more effective method of construction.

Note that in this section on wall framing the phrase 'Conventional Double-Wall' is used. Conventional may be a word that is used prematurely in a relatively new field still seeing many changes. For the purpose of this report we are referring to the type of double-wall construction most commonly incorporated today.

.2 Lighting

Care must be taken in the selection of lighting for residences. Fluorescent lighting has a few limitations that may outweigh the reduced operating costs and extended life span associated with fluorescent lighting. Some of these limitations are; higher fixture cost, more difficult and expensive to control, higher cost of replacement bulbs, not as versatile as incandescent, more stimulating than relaxing and not as good colour rendition. It is our opinion that incandescent lighting is better suited to a residential environment than fluorescent. A home requires light to set moods, enhance colour, relax the occupants and generally be variable. This is better accomplished with incandescent lighting.

Most of the fixtures in this residence are ceiling mounted. A disadvantage of mounting any type of fixture on the ceiling is the penetration through the air/vapour barrier due to electrical connections. This poses another area of potential air leakage into the attic if special consideration is not given to sealing around wires that lead into the attic from both the fixture and the switch that controls it. It would be our recommendation to limit the number of ceiling fixtures as much as possible.

.3 Ventilation

The heat exchanger used in this residence is not adequate to handle the pressure of the attached ductwork. The VL-1500 is rated at only 71 cfm with no ductwork. There was no indication of air flow at the duct inlets located in the kitchen and the bathrooms. This type of heat exchanger is meant for window installation to exchange the air in a room and has been misapplied. A number of residential central exhaust heat exchangers are available for this type of application. One of them should have been used here.

.4 Heating

The heating system design for this house, has also been used in Low Energy houses in the Saskatoon area, and although relatively new for residential heating, it does provide an effective method for homes with low heating loads. The cost of the system is low as compared to a gas or electric furnace. Sizing of the system can be done to closely meet the heat loss of the house rather than by 5 kW increments. It does not utilize non-renewable fuel, and the electric service does not have to be as large as that of a house using an electric furnace. We would recommend the use of this type of heating system in low-energy homes.

.5 Windows

The advantage of having triple glazed windows and the majority of window areas on the south exposure is obvious.

The unique feature of having the windows located on the inside of the double wall has the advantage of allowing the air supply (from the diffusers located directly below the windows) to sweep the inside glass surface to reduce build-up of condensation on the inside surface.

We do not see any direct energy saving advantage to this feature, and suggest that it should be done as a matter of individual preference.

.6 Floor Joist/Foundation Wall Intersection

The method of providing insulation at the intersection is well suited for concrete foundation. It provides a continuous layer of insulation over the header, as well as the ends of the floor joists, around the entire perimeter of the house. Insulating from the interior can only be done between the joists. The Neufeld residence uses both methods, sealing the polystyrene on the interior to the joists, subfloor and basement wall framing. It was noted that the polystyrene was not covered with a fire retardant such as drywall as required by the Fire Code. Not only does the drywall act as a fire retardant but it also provides a smooth, hard surface making caulking easier and more effective.

.7 Basement Wall

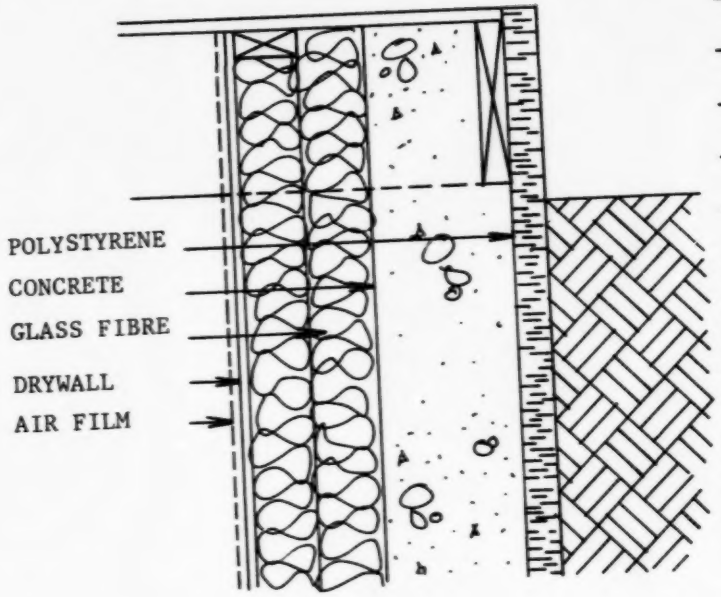
The method used for insulating the basement wall will help to prolong the life of the concrete.

Added advantages of insulating the foundation wall from the outside (other than the obvious resistance to heat flow) are moisture and freeze protection. Refer to the temperature profile chart (Figure 7). Even though the wall is insulated from the inside the exterior insulation provides enough resistance to heat flow to prevent the foundation wall from falling below the freezing point.

.8 Basement Floor

From the heat loss calculation in Appendix A one can see that the heat loss of .887 KW for the basement floor accounts for over 20% of the total loss of 4.3 KW. Without insulation the estimated heat loss of the basement floor is 6.5 KW or 66% of the total loss.

The insulation of the basement floor is a major factor in the reduction of the heating load in low energy homes.



	R	R/R_T	ΔT	T
				20° C
Inside Air Film	.12	.003	.072	
				19.9
½" Drywall	.45	.011	.26	
				19.6
R-28 Glass Fibre	28	.71	17	
				2.6
8" Concrete	.9	.023	.55	
				2
R-10 Polystyrene	10	.25	6	
				-4° C
TOTAL	39.47	1	24	

FIGURE 4.8
A TEMPERATURE PROFILE CHART

* Lowest temperature taken from a Winnipeg Meteorological Summary 1968-1972 (8 year average) of soil temperature 20 cm below grade.

FIGURE 7

.9 Attic Ventilation

Turbine type vents would not be necessary in this house because of the concentrated efforts on sealing the attic against air leakage, which greatly reduces the need for ventilation. The house would be as well served by a few roof vents or a continuous ridge vent, which can be installed at less than half the cost.

5. TESTS AND CALCULATIONS

.1 NRC Calculations

Heat loss calculations as well as energy consumption and predicted fuel costs for the Neufeld house where estimated by a computer at the National Research Council in Saskatoon. The complete data print-out is found in Appendix A. The heat loss calculations estimates a heating load of less than 5 kW which is typical for a low energy house in Manitoba. Some of the building areas for the NRC calculations are incorrect because they are based on house plans that differ from 'as built' construction plans. Our (SMS) calculations, also found in Appendix A indicate about the same results as NRC.

	DESIGN HEAT LOSS (kW)	ANNUAL CONS. FOR SPACE HTG. (kWh)	ANNUAL CONS. FOR SPACE HTG. ($)
NRC	4.766	5752	156
SMS	4.305	6372	161

Both calculations indicate an exceptionally low heating cost. The energy required for heating is accurately metered for this home. It will be interesting to compare the estimated consumption with actual after the first full heating season of occupancy.

.2 Air Leakage Test Description

The air leakage test was performed by a Winnipeg company, Ener-Corp Management Ltd. using a machine called the 'Infiltrometer'. The Infiltrometer (see Appendix B) is placed in a doorway and by the use of a fan creates a negative pressure inside the building. Corresponding pressure readings of the differential across the wall of the house and at the throat of the air flow measuring nozzle are taken. A series of these points form the characteristic curve for that particular building. The computer print-out for the Neufeld residence as well as the description of the data are found in Appendix B. The print-out illustrated in Appendix B is a re-run of the original test taken. Since the original test was taken the computer program has been updated by Ener-Corp using the same pressure reading we were able to come up with a more accurate set of data. The characteristic curve has also been plotted in Appendix B to more clearly illustrate what the curve would look like had it been plotted manually on full log paper.

6. COMPARATIVE EVALUATION

It was mentioned earlier in this report that three of the main factors in determing the effectiveness of Low Energy houses was usually the insulation levels, the minimizing of natural air change and glazing orientation. Unfortunately glazing orientation is a factor that has not been well documented, so the comparative evaluation will concentrate on insulation levels and air leaking characteristics. To assist in our comparison of insulation levels we have in Table No. 1, Appendix C charted the various levels for the following homes.

.1 The Manitoba Hydro Super Energy Efficient Home (SEEH).

.2 The 1980 Canadian Energy Association Standards (1980 CEA).

.3 The 1978 Manitoba Building Code (1978 MBC).

.4 The Saskatchewan Conservation House (SCH).

.5 Energy Efficient Flair Home - Project #3 (FH#3).

.6 Carroll Residence, Swan River (Underground house).

.7 Neufeld Residence, Steinbach.

From Table No. 1 it can be seen that the Neufeld homes does not lack in insulation as compared to the other houses having levels greater than or equal to them.

The calculated annual energy consumption for the Neufeld residence is compared with four other homes as shown below.

	$GJ/m^2/yr.$	$kWh/ft.^2/yr.$
Neufeld Residence	.093	2.39
Carroll Residence	.16	4.24
SEEH	.11	2.98
CEA	.37	9.68
MBC	.68	17.87

NOTE: Basement areas are included in analysis. As seen in the above table the Neufeld residence would be expected to surpass any existing standards as well as most other low energy homes.

Table No. 2 in Appendix C is a comparison of air leakage characteristics of low energy homes in the Winnipeg area tested by the Infiltrometer. Again by using the figure located in the relative tightness column we can see that the Neufeld residence fares quite well amongst other low energy homes in respect to air leakage.

In general the design and construction techniques implemented in the Neufeld set it apart from any conventional house as well as most low energy homes. Not only is the house designed to be low in energy consumption, but designed to be unique and innovative. Along with the usual low energy features such as; large amounts of insulation, air-to-air heat exchanger, detailed sealing etc., it is the innovative features such as; the 'I-Beam' wall design, the roof design, and the heating system that make the designer/builder a few steps ahead in an industry that is constantly experimenting trying to find better techniques of building low energy house.

APPENDIX A - CALCULATIONS

Heat Loss by NRC and SMS

HENRY DUECK
P.O. BOX 1655 STEINBACH MAN R0A 2A0 326-9868

1981 - APR - 3

BUILDING PARAMETERS

ELEMENT	AREA m2	RSI VALUE m2-DegC/W	HT LOSS W/DegC	% HT LOSS SEASONAL %
CEILING	123.79	10.57	11.71	10.87
WALLS	118.96	8.45	14.07	13.05
BASEMENT AB.GD.	27.88	6.69	4.17	3.86
BASEMENT BL.GD.	91.08	6.69	12.03	8.92
FLOOR	123.79	2.64	28.12	20.87
DOORS	3.30	2.66	1.24	1.15
WINDOWS, SOUTH	6.55	0.52	12.62	11.70
NORTH	1.23	0.56	2.20	2.04
EAST	1.19	0.56	2.12	1.96
WEST	4.37	0.56	7.80	7.23
AIR CHANGE 0.100/HR		641.18	19.78	18.34

DESIGN HEAT LOSS -34.0C = 4.766KW
ANNUAL HEAT LOSS BASED ON DEGREE DAY METHOD(GIGAJOULES) 44.9189

MONTHLY SUMMARY OF ENERGY CONSUMPTION

MONTH	THERMAL LOAD MJ/DAY	MONTHLY SOLAR FRAC	AUX HEAT REQ MJ/DAY	TOT CONS KW-HR/DAY
J A N	230.610	0.27	169.09	80.97
F E B	210.989	0.39	128.66	69.74
M A R	163.898	0.54	75.31	54.92
A P R	87.376	0.73	23.70	40.58
M A Y	34.399	0.97	1.19	34.33
J U N	0.000	1.00	0.00	34.00
J U L	0.000	1.00	0.00	34.00
A U G	0.000	1.00	0.00	34.00
S E P	36.361	0.95	1.96	34.55
O C T	80.181	0.65	28.28	41.86
N O V	149.509	0.31	103.22	62.67
D E C	199.870	0.23	153.16	76.55

ESTIMATED ANNUAL SPACE HEATING 20.7071 GJ, OR 5751.98 KWHRS

ANNUAL PREDICTED FUEL COSTS

ENERGY SOURCE	COST PER UNIT	SPACE HEATING	HOT WATER	LIGHTS AND APPLIANCES
ELECTRICITY	2.720c/KWH	$ 156.45/YR EFF.= 100%	$ 168.78/YR EFF.= 100%	$ 168.78/YR EFF.= 100%
NATURAL GAS	$ 2.45/MCF	$ 68.70/YR EFF.= 70%	$ 94.32/YR EFF.= 55%	--
O I L	20.00c/LITER	$ 151.70/YR EFF.= 70%	$ 208.28/YR EFF.= 55%	--
PROPANE	15.72c/LITER	$ 181.65/YR EFF.= 70%	$ 249.40/YR EFF.= 55%	--
WOOD	$ 90.00/CORD	$ 200.39/YR EFF. 50%	$ 270.22/YR EFF.40%	--

SUMMARY OF HOUSE CONSTRUCTION DATA AND CALCULATED NET HEAT LOSS COMPONENTS

DESCRIPTION		ORIENTATION				TOTAL FOR ALL ORIENTATIONS
		NORTH	SOUTH	EAST	WEST	
WINDOWS	Area, m^2	1.08	6.84	1.37	3.96	13.25
	Heat Loss Factor, kWh/m^2	160	-142	75	75	
	Heat Loss, kWh/yr	173	-971	103	297	-398
EXTERIOR WALLS	Area, m^2	36.12	30.36	20.93	18.34	105.75
	Resistance, m^2K/W	8.4	8.4	8.4	8.4	
	Heat Loss Factor, khK	128	94	113	113	
	Heat Loss, kWh/yr	550	340	282	247	1419
BASEMENT WALLS ABOVE GRADE	Area, m^2	4.6	4.6	2.8	2.8	14.8
	Resistance, m^2K/W	6.9	6.9	6.9	6.9	
	Heat Loss Factor, khK	128	94	113	113	
	Heat Loss, kWh/yr	85	63	46	46	240
EXTERIOR DOORS	Area, m^2	4	2	-	-	6
	Resistance, m^2K/W	1.4	2.3	-	-	
	Heat Loss Factor, khK	128	94	-	-	
	Heat Loss, kWh/yr	366	82	-	-	448
CEILING	Area, m^2	123.8				123.8
	Resistance, m^2K/W	10.6				
	Heat Loss Factor, khK	92				
	Heat Loss, kWh/yr	1074				1074
INFILTRATION	Average Infiltration Rate, m^3/h	37 **				
	Heat Loss Factor, kWh^2/m^3	47				
	Heat Loss, kWh/yr	1739				1739
TOTAL HEAT LOSS =						4522

**It should be noted that in the case of exterior walls, doors etc., the annual heat loss in kWh is the product of the area and the heat loss factor divided by the resistance.*

**** Taken from infiltrometer print-out.**

Continued

Loss From Net Annual Calculation 4,522 kWh/yr.

Basement Wall Below Grade = 1,120 ft.²

$$\frac{1{,}120 \text{ ft.}^2 \times 35^\circ \text{ F.T.D.} \times .0256 \text{ Btu/h/ft.}^2/^\circ\text{F}}{3{,}413 \text{ Btu/h/kW}} = .294\text{kW}$$

Basement Floor

$$\frac{1{,}332 \text{ ft.}^2 \times 25^\circ\text{F.T.D.} \times .0909 \text{ Btu/h/ft.}^2/^\circ\text{F}}{3{,}413 \text{ Btu/h/kW}} = .887\text{kW}$$

1.181kW

1,480* x 1,181 kW = 1,750 kWh

\+ 4,522 kWh

6,372 kWh Est. Annual Consumption

$$\frac{6{,}372 \text{ kWh}}{1{,}480} = \underline{\underline{4.3 \text{ kW}}} \text{ Heat Loss}$$

* $\frac{\text{Degree Days X Daily Average Hours of Operation}}{\text{Design Temperature Difference}}$

APPENDIX B

The Infiltrometer and Air Leakage Tests

"Air Leakage and the Infiltrometer"

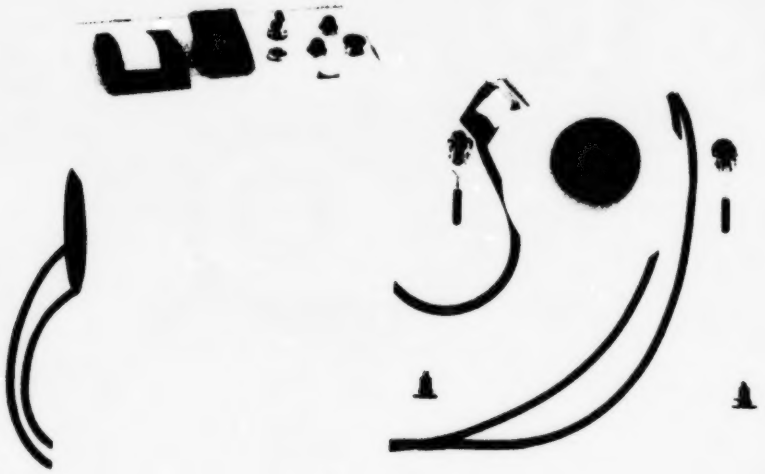
The importance of reducing uncontrolled air leakage in residential dwellings cannot be over-emphasized. It is the major component of heat loss in almost every home in North America.

The Canadian Government has recently established a committee on Airtightness of Buildings, charged with the responsibility of developing an airtightness standard for residential construction. The National Research Council of Canada has recognized the importance of airtightness in a number of its publications.[1]

infiltrometer

ener-corp

THE ENERGY MANAGEMENT COMPANY



A number of research organizations in the United States have drawn some startling conclusions in the air leakage work they have been involved in. Princeton University, for instance, have determined that "...house-to-attic warm air leaks...result in the waste of almost 20% of all the home heating energy (2% of all energy) used in the United States. That is equivalent to wasting over 600,000 barrels of oil a day."[2]

Lawrence Berkeley Laboratory have concluded in one of their publications[3] that "for homes in the United States...air leakage imposes a 30% to 40% burden on the energy load of a typical house."

Based on air leakage measurement practices developed in Sweden, the American Society for Testing and Materials (ASTM) has proposed a standard for air leakage measurement by the fan pressurization method.

The Infiltrometer has been designed to exceed all requirements of the proposed standard. The result is a device capable of automatically and accurately determining the air change rate of virtually every single detached residential structure in North America. Field data and results are recorded by an electronic printer to add a significant degree of integrity to this sophisticated device.

Copies of the above-noted publications and other informational data is available on request.

Call Toll Free
1-800-228-2606
24 hours a day—7 days a week

1. HANDEGORD, G. O., The Need for Improved Airtightness in Buildings. National Research Council of Canada, Division of Building Research, Building Research Note No. 151.
2. DUTT, G. S., If Home Energy Saving is such a Good Idea, Why don't more People do it?, Appendix A, Centre for Energy and Environmental Studies, Princeton, University.
3. GRIMSRUD, D. T., et al., Calculating Infiltration: Implications for a Construction Quality Standard, Energy and Environment Division, Lawrence Berkeley Laboratory.

ENER-CORP MANAGEMENT LIMITED **HEAD OFFICE:** 2 Donald Street, Winnipeg, Manitoba, Canada R3L 0K5 (204) 477-1283
EASTERN CANADA: 440 St. Joseph Boulevard, Hull/Ottawa J8Y 3Y7 (819) 777-4446
UNITED STATES: 359 Route 111, Smithtown, New York 11787 (516) 724-2111

ENER-SEAL

VOL/AREA/TEMP/PRES

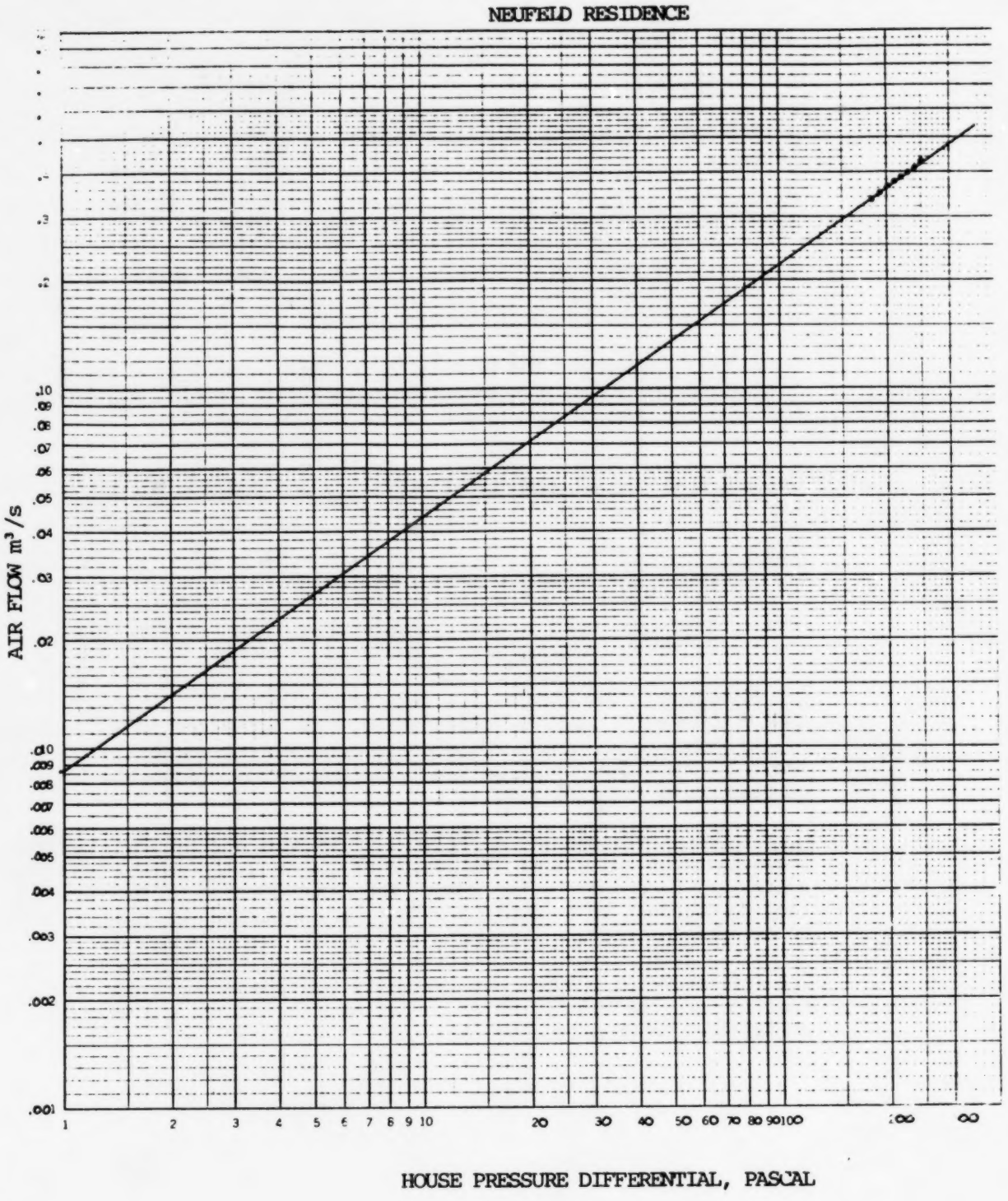
682.	M↑3 ← Gross Heated Volume, m^3
260.	M↑2 ← Gross Exposed Surface Area, m^2
20.	TEMP ← Inside Air Temperature, °C
101.	PRES ← Barometric Pressure, kilopascals

H. PRS/N. PRS/FLOW

250.	HP ← House Pressure, Pascals
770.	NP ← Nozzle Pressure, Pascals
424.2240281	Q ← Flow Rate, litres per second
240.	HP
715.	NP
408.7622085	Q
230.	HP
685.	NP
400.0777382	Q
220.	HP
645.	NP
388.197583	Q
210.	HP
610.	NP
377.4971328	Q
200.	HP
565.	NP
363.2784889	Q
190.	HP
520.	NP
348.4825895	Q
180.	HP
480.	NP
334.784444	Q

.9984110667 ← Correlation Coefficient

.0181785878	M↑2 ← Equivalent Leakage Area, m^2
.7183320369	50PA ← Air Changes Per Hour @ 50 Pascals
.0570950676	I ← Infiltration Rate
.1680121018	MM/S ← Relative Tightness, mm/s
.0085957696	C ← Flow Coefficient, $m^3/s.\ Pa^N$
.7060291486	N ← Flow Exponent, dimensionless


NEUFELD RESIDENCE
AIR FLOW m³/s
.10
.09
.08
.07
.06
.05
.04
.03
.02
.010
.009
.008
.007
.006
.005
.004
.003
.002
.001
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
∞
HOUSE PRESSURE DIFFERENTIAL, PASCAL

Description of Data

The input and output data of the Neufeld residence air leakage test, before and after sealing, is shown in Figure 8. The characteristic curve has also been plotted in Figure 9. This data will now be described in detail.

Heated Volume: The total heated volume of a structure is required to enable the air change rate at a 50 pascal pressure differential to be determined. This item is also required to calculate the infiltration rate.

The Exposed Surface Area: This piece of information is necessary to determine the specific air flow rate of the structure.

The Inside Temperature: Because the density of air varies with temperature, the air flow rate through the nozzle must be corrected so that all air flow rates are reported at the same air density.

Barometric Pressure: The density of the air is also affected by the barometric pressure. For this reason this item is also required so that the appropriate correction factor can be applied.

In each case, the air flow rate is corrected and printed to report the air flow rate at standard temperature and pressure conditions, that is, 20 deg. C and 102 kilopascals.

House Pressure: This is the envelope pressure produced by the Infiltrometer and is measured in pascals.

Nozzle Pressure: This is the pressure created by the air flow at the throat of the nozzle, and is measured in pascals.

Air Flow Rate: The nozzle is a carefully calibrated, long radius ASME nozzle with known characteristics. The relationship between the nozzle pressure and the air flow rate has been determined in the laboratory and the nozzle pressure is then used to calculate the corresponding air flow rate.

Correlation Coefficient: In order to determine the accuracy of the pressurization data, some indication of how well the points 'fit' on a straight line must be included. The determination of the correlation coefficient is a complicated but very accurate means of ensuring an acceptable 'fit'.

The Infiltrometer program automatically calculates the correlation coefficient, but will print no output data unless the correlation coefficient is greater than .98.

Equivalent Leakage Area (ELA)

This item is a measure of the 'hole' size in the envelope of the structure. The accepted means of calculating this value is based on the equation for turbulent flow through a sharp edged orifice in a thin wall. in the laboratory, it has been found to correlate well with the actual size of a hole introduced into the envelope.

Air Change Rate at 50 Pascal Pressure Differential

The air change rate is the number of times that the entire air volume within the structure changes each hour at a specific pressure differential. The pressure differential of 50 pascals is somewhat arbitrary but was selected to conform with the reference pressure used internationally to report air change rates. This value is determined by dividing the air flow rate per hour at a 50 pascal pressure differential by the heated volume of the structure.

'I' Infiltration Rate

It is important to note that air tightness testing will not necessarily result in an accurate determination of the infiltration rate. This is because the infiltration rate is dependent upon many factors which are peculiar to each structure, such as the internal resistance offered by the walls, floors, etc., the location of the holes in the envelope of the structure, the proximity to other buildings, etc. It has therefore been difficult to establish an accurate correlation between depressurization data and the infiltration rate.

Recently, the National Research Council of Canada published a paper in which such a correlation was presented. The report suggests that the depressurization data can be used to predict the infiltration rate with some degree of accuracy, say, plus or minus 25%. The infiltration rate calculated and printed is based on this research paper. It should be reiterated that the infiltration, or air change rate, is not a constant but varies with the outside temperature as well as the wind speed and direction.

Relative Tightness

This item is very useful for comparing the air tightness of different sized structures. The relative tightness can be thought of as the specific air flow rate, in which the measured air flow rate at a particular pressure differential is divided by the gross exposed surface area to produce an air flow rate per square meter. one can then logically compare different sized structures on the basis of relative tightness. It should be noted that the units of relative tightness are millimeters per second, which can be considered the average velocity of the air entering the structure.

The relative tightness can be calculated at any pressure differential, but 10 pascals has been chosen to correspond with the pressure at which the ELA is determined.

The relative tightness of the different structures can vary widely depending on the construction techniques employed and the attention to details shown by the original contractor.

Leakage or Flow Coefficient

The definition of this item is that it is equal to the value of the flow rate when the pressure differential across the envelope of the structure is 1 pascal. This item is very useful for reporting the results of the air leakage tests, as it is one of the two items required to reproduce the leakage curve without the necessity of recording all of the pressure data.

Leakage or Flow Exponent

The flow exponent is the slope of the air leakage curve when corresponding values of flow rate and pressure are plotted on full log graph paper. From the physics of air flow, this value must always be above 0.5 but not greater than 1.0.

This item is useful for two reasons: Its value, along with the leakage coefficient, can be used to generate the leakage curve with no additional pieces of information being required and the flow exponent can be used to indicate the size of holes that predominate the air leakage.

In general terms, if the value of the flow exponent is in the vicinity of .55, then the predominant holes in the envelope of the structure are relatively large, that is, greater than 2mm. If the flow exponent is towards the opposite end of the scale say .85 then the type of air leakage points would be relatively fine, such as hair line cracks along baseboards.

APPENDIX C

COMPARISON TABLES

HOUSE	INSULATION LEVEL (R-VALUE)				DESIGN HEAT LOSS (kW)
	ROOF	WALL	BSMT. WALL	FLOOR	
Neufeld Residence ($124m^2$)	60	48	38	10	4.3
Carroll Residence ($280m^2$)	43	30	37	-	7.7
SEEH ($103m^2$)	56	40	30	6	4.0
1980 CEA ($103m^2$)	40	20	12	-	13
1978 MBC ($103m^2$)	33	12	7 to 2' Below grd.	-	24
SCH	60	44	20	-	-
FH#3 ($98m^2$)	55	47	27	-	4.5

TABLE 1

COMPARISON OF INSULATION LEVELS IN LOW ENERGY HOMES

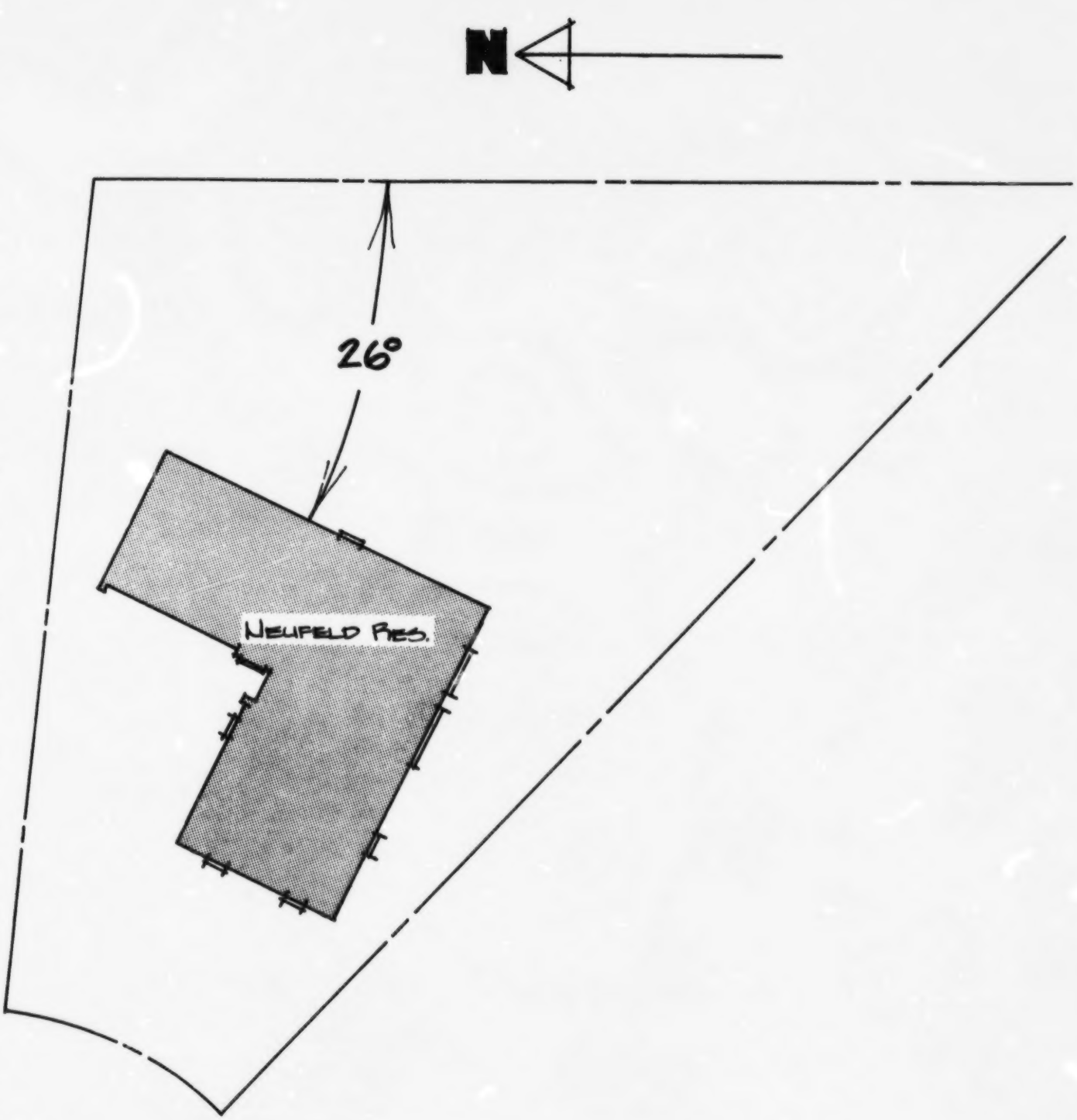
House Type	Equivalent Leakage Area m^2	Air Changes Per Hour @ 50 Pa	Flow Coeff., (C) $m^3/s\ Pa^N$	Relative Tightness mm/s	Flow Exponent N
Neufeld Residence	.018	.72	.008	.17	.72
Four Level Split	.028	1.30	.014	.25	.69
Single Storey with Basement	.021	1.40	.010	.28	.68
Single Storey with Basement	.005	.27	.002	.05	.75
Two Storey with Crawlspace	.003	2.05	.014	.31	.76
Two Storey with Basement	.005	2.05	.031	.42	.63

TABLE 2

AIR LEAKAGE CHARACTERISTICS OF LOW ENERGY HOMES (WINNIPEG AREA)

APPENDIX D

SITE PLAN


N
26°
NEUFELD RES.

APPENDIX E

LOSSNAY HEAT EXCHANGER

MITSUBISHI ELECTRIC
INDUSTRIAL PRODUCTS

MITSUBISHI Lossnay

Air-to-Air Enthalpy Heat Exchanger

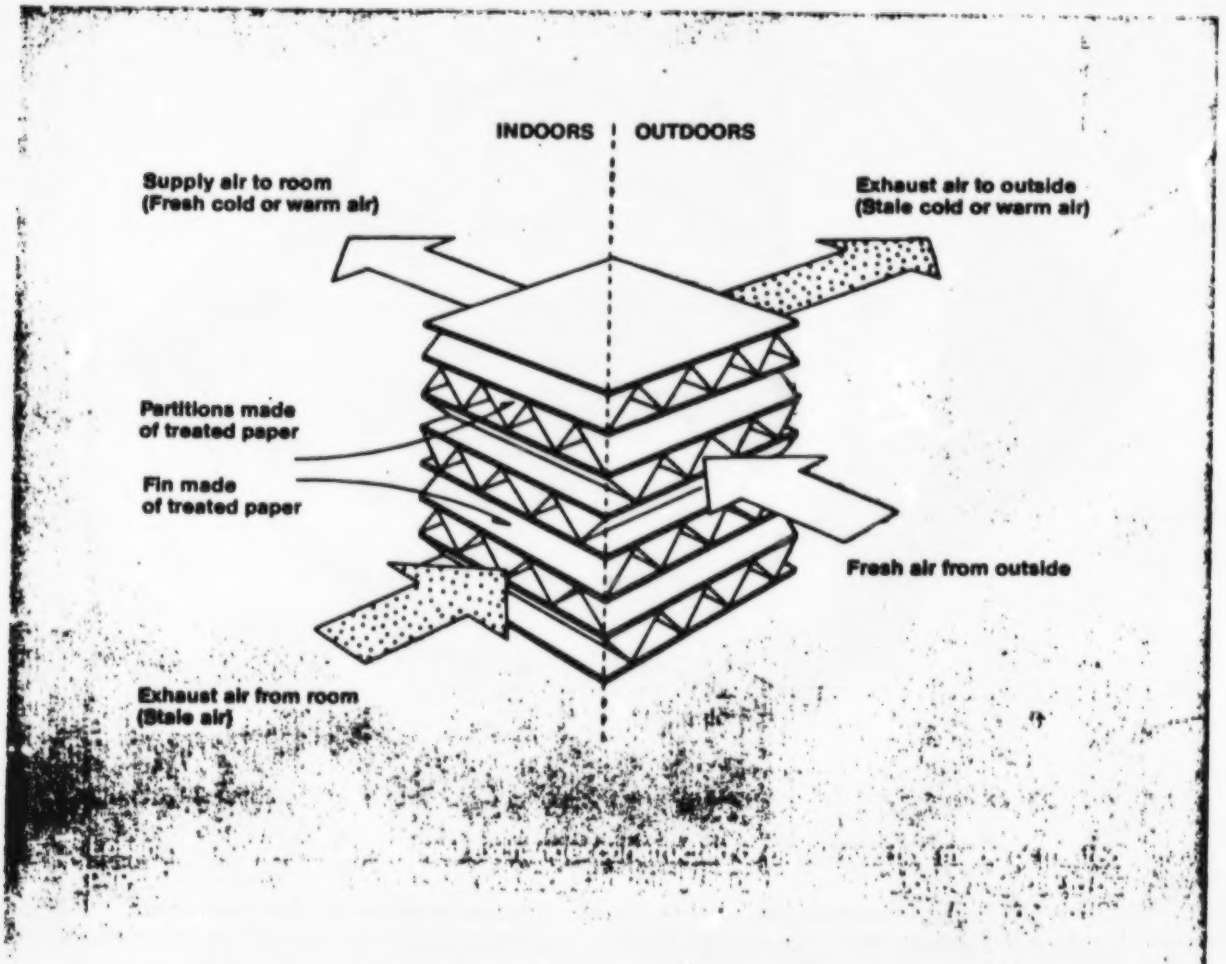
CONSTRUCTION

When heating or cooling indoor living environments, ventilation is required to replace the stale air in the system. Fresh air, however, reduces the efficiency of heaters and air conditioners, resulting in wasteful energy loss and higher operating costs.

Lossnay was developed by placing special emphasis on the volume of fresh air used in relation to the equipment and associated operational expenses. Lossnay successfully introduces fresh air into the system while effectively conserving cooling and heating energy. Clean and economical ventilation is possible without loss of cooling or heating efficiency.

The Lossnay element is an embedded total heat exchanger constructed of cross laminated plates and fins. The lamination layers consist of specially treated paper partition plates with corrected spacers made of paper. As fresh air replaces stale air, the element exchanges latent heat (humidity) and sensible heat. (temperature).

In recent years, overall efficiency has become a prerequisite in every energy system. The Lossnay heat exchanger represents a significant advance in the effective utilization of resources.



Lossnay

PRINCIPLE

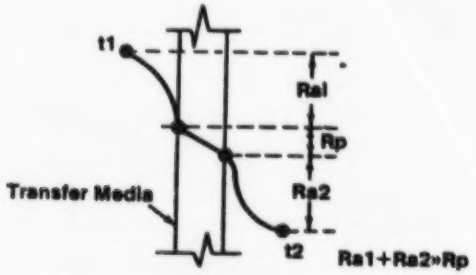
Lossnay's principle of operation is based on the heat transfer properties and moisture permeability of treated paper. Total heat (sensible heat plus latent heat) is transferred to the fresh air being introduced into the system via the medium of treated paper. This principle is easy to understand if you conduct this simple experiment:

Roll a sheet of paper into a tube and blow through it. Your hand holding the paper will immediately feel warm. If cold air was blown through the paper, your hand would feel cool. Thus, heat is readily transferred via a paper medium.

Total Heat Exchanging Mechanism

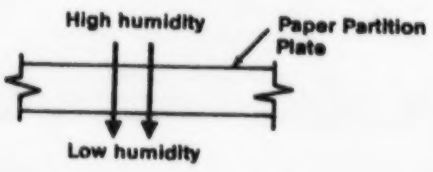
Sensible heat exchange

Sensible heat is transferred from higher to lower levels of the element. Although paper is usually regarded as a heat insulating material, it exhibits as far as gas-to-gas phases are concerned, a high thermal conductivity comparable to copper and aluminum (a 3% maximum thermal conductivity difference).



Latent heat exchange

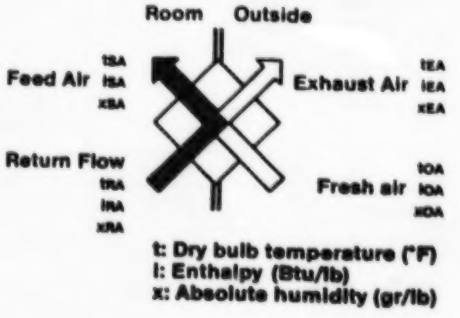
Latent heat is transferred from higher to lower levels of the element because of partial pressure differences. Capillarity caused by condensation on the element is not always a prerequisite to latent heat exchange and the element is not always moistened even under highly humid conditions. Energy is released when condensation occurs and gained after the osmosis.



CALCULATION OF TOTAL HEAT EXCHANGING EFFICIENCY

The total heat exchange efficiency of the Lossnay element can be determined by calculating the following 3 heat transfer rates.

	Heat-transfer rate at feed side	Heat-transfer rate at exhaust side
Sensible heat-transfer rate	$\eta t = \frac{t_{OA} - t_{SA}}{t_{OA} - t_{RA}}$	$\eta t' = \frac{t_{EA} - t_{RA}}{t_{OA} - t_{RA}}$
Enthalpy transfer rate	$\eta i = \frac{t_{OA} - t_{SA}}{i_{OA} - i_{RA}}$	$\eta i' = \frac{i_{EA} - i_{RA}}{i_{OA} - i_{RA}}$
Latent heat-transfer rate	$\eta x = \frac{X_{OA} - X_{SA}}{X_{OA} - X_{RA}}$	$\eta x' = \frac{X_{EA} - X_{RA}}{X_{OA} - X_{RA}}$



t: Dry bulb temperature (°F)
I: Enthalpy (Btu/lb)
x: Absolute humidity (gr/lb)

Calculating the Conditions of Fresh Air and Exhaust Air

If Lossnays heat transfer rate and conditions of both the room and outside air are known, the conditions of both the air entering the room and the air exhausted to the outside can be determined from the following formulas.

	Feed side	Exhaust side
Temperature	$t_{SA} = t_{OA} - (t_{OA} - t_{RA}) \cdot \eta t$	$t_{EA} = t_{RA} + (t_{OA} - t_{RA}) \cdot \eta t'$
Enthalpy	$i_{SA} = i_{OA} - (i_{OA} - i_{RA}) \cdot \eta i$	$i_{EA} = i_{RA} + (i_{OA} - i_{RA}) \cdot \eta i'$
Humidity	$X_{SA} = X_{OA} - (X_{OA} - X_{RA}) \cdot \eta x$	$X_{EA} = X_{OA} + (X_{OA} - X_{RA}) \cdot \eta x'$

Lossnay

PERFORMANCE COMPARISONS WITH VARIOUS HEAT EXCHANGERS AND VENTILATORS

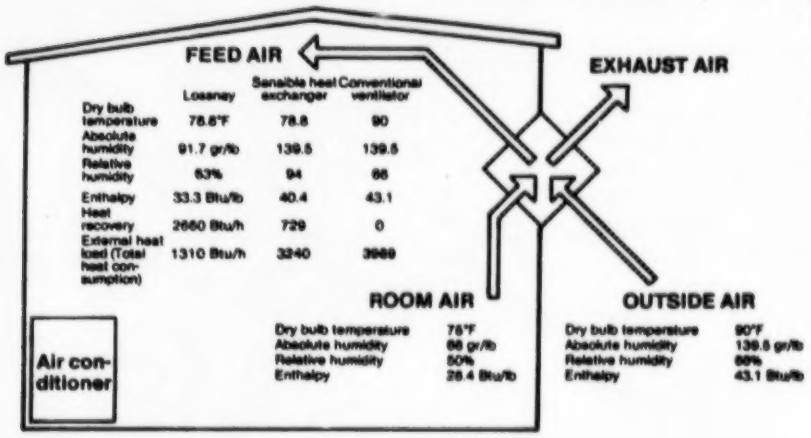
To measure performance parameters, Lossnay's heat recovery and external heat load was compared to various sensible heat exchangers and conventional ventilators.

The sensible and latent heat transfer rates of Lossnay were assumed to be 75% and 65% respectively, while the heat transfer rate of the sensible heat exchanger was assumed to be 75%.

	Lossnay	Sensible heat exchanger	Conventional ventilator
Sensible heat	75	75	0
Latent heat	65	0	0

***Heat-transfer rate (%)**

***Ventilating rate: 60 CFM (Specific gravity of air: 0.0749lb/ft³) (Power consumption required to ventilate 60 CFM: 45W)**



Calculation Formulas

Lossnay

(Lossnay feed side outlet temperature) tSA = 90°F − (90°F − 75°F) x 0.75 = 78.8°F
(Lossnay feed side outlet humidity) xSA = 139.5 − (139.5 − 66) x 0.65 = 91.7 gr/lb
(Lossnay feed side outlet enthalpy) ISA = 33.3 Btu/lb (from graph)

(Lossnay exhaust side outlet temperature) tEA = 75°F + (90°F − 75°F) x 0.75 = 86.3°F
(Lossnay exhaust side outlet humidity) xEA = 66 + (139.5 − 66) x 0.65 = 113.8 gr/lb
(Lossnay exhaust side outlet enthalpy) IEA = 38.3 Btu/lb (from graph)

Heat recovery per hour = (43.1 − 33.3) x 4.5 x 60 = 2660 Btu/h
External heat load = (33.3 − 28.4) x 4.5 x 60 = 1310 Btu/h

Sensible heat exchanger

(Feed side outlet temperture) tSA = 90°F − (90°F − 75°F) x 0.75 = 78.8°F
(Feed side outlet humidity) xSA = 139.5 gr/lb
(Feed side outlet enthalpy) ISA = 40.4 Btu/lb

(Exhaust side outlet temperature) tEA = 75°F + (90°F − 75°F) x 0.75 = 86.3°F
(Exhaust side outlet humidity) xEA = 66 gr/lb
(Exhaust side outlet enthalpy) ISA = 31.2 Btu/lb

Heat recovery per hour = (43.1 − 40.4) x 4.5 x 60 = 729 Btu/h
External heat load = (40.4 − 28.4) x 4.5 x 60 = 3240 Btu/h)

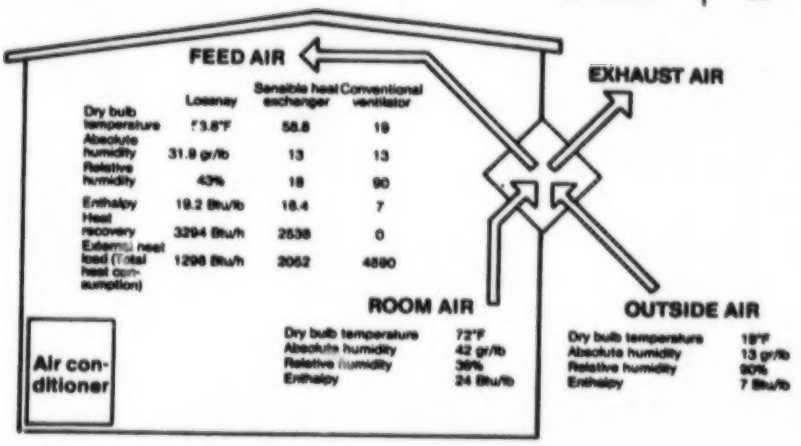
Conventional ventilator

If conventional ventilator is used, the feed air temperature is equal to the exhaust air temperature and heat is not recovered.
External heat load - (43.1 − 28.4) x 4.5 x 60 = 3969 Btu/h

	Lossnay	Sensible heat exchanger	Conventional ventilator
Sensible heat	75	75	0
Latent heat	65	0	0

***Heat-transfer rate (%)**

***Ventilating rate: 60 CFM (Specific gravity of air: 0.0749 lb/ft³) (Power consumption required to ventilate 60 CFM: 45W)**



Calculation Formulas

Lossnay

(Lossnay feed side outlet temperature) tSA = 19°F − (19°F − 72°F) x 0.75 = 58.8°F
(Lossnay feed side outlet humidity) xSA = 13 − (13 − 42) x 0.65 = 31.9 gr/lb
(Lossnay feed side outlet enthalpy) iSA = 19.2 Btu/lb (from graph)

(Lossnay exhaust side outlet temperature) tEA = 72°F + (19°F − 72°F) x 0.75 = 32.3°F
(Lossnay exhaust side outlet humidity) xEA = 42 + (13 − 42) x 0.65 = 23.2 gr/lb
(Lossnay exhaust side outlet enthalpy) iEA = 11.6 Btu/lb (from graph)

Heat recovery per hour = (19.2 − 7) x 4.5 x 60 = 3294 Btu/h
External heat load = (24 − 19.2) x 4.5 x 60 = 1296 Btu/h

Sensible heat exchanger

(Feed side outlet temperature) tSA = 19°F − (19°F − 72°F) x 0.75 = 58.8°F
(Feed side outlet humidity) xSA = 13 gr/lb
(Feed side outlet enthalpy) iSA = 16.4 Btu/lb (from graph)

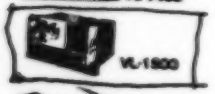
(Exhaust side outlet temperature) tEA = 38°F (from graph)
(Exhaust side outlet humidity) xEA = 34 gr/lb (from graph)
(Exhaust side outlet enthalpy) iEA = 14.5 Btu/lb (from graph)

Heat recovery per hour = (16.4 − 7) x 4.5 x 60 = 2538 Btu/h
External heat load = (24 − 16.4) x 4.5 x 60 = 2052 Btu/h

For conventional ventilator

If a conventional ventilator is used, the feed air temperature is equal to the exhaust air temperature and heat is not recovered.
External heat load = (24 − 7) x 4.5 x 60 = 4590 Btu/h

22" x 8" x 11"



22" x 15" x 12"

23" x 17" x 12"

Model	Capacity (CFM)	Power Source (V)	Power Consumption (W)	Heat Exchanging Efficiency (%)	Weight (Lbs)
VL-1400	54	117	35	61	19
VL-1500	71	117	56	70	27
V-1200	57	117	47	60	17
VL-1500Z	62	117	51	70	29
VL-500B	24	117	31	65	7

40" x 13" x 28"

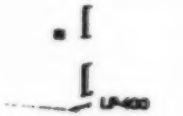
LGF-40L	212	117	240	69	122

53" x 13" x 35"

LGH-10R	71	117	54	70	41
LGH-50E	277	117	280	72	188
LGH-50R					

22" x 44" x 13"

LT-70A	412	220	270	70	166
LT-100A	589	220	420	73	245



102" x 40" x 85"

Model	Capacity (CFM)	Power Source (V)	Power Consumption (KW)	Heat Exchanging Efficiency (%)	Static Pressure (in. WG)	Weight (Lbs)
LP-200	1,177	220	1.5kW x 2	75	0.63	1,103
LP-400	2,354	220	2.2kW x 2	75	0.79	1,632
LP-600	4,709	220	3.7kW x 2	75	0.79	3,967
LP-1200	7,063	220	5.5kW x 2	75	0.39	5,953

34" x 83" x 34"

Model	Standard Capacity CFM	Heat Exchanging Efficiency (%)	Enthalpy Transfer Rate %		Pressure Drop (in. WG)	Weight (Lbs)
			Summer	Winter		
LS-60N	470	77	66	71	0.55	119
LS160N	940	77	66	71	0.86	188
LS-500	2940	72	62	67	1.26	552

	LS-500 Combination Type			LS-160N Combination Type		
	Combination No.	Number of Units	Standard Capacity (CFM)	Combination No.	Number of Units	Standard Capacity (CFM)
LUH	LUH-502	2	5890	LUH-1602	2	1885
	503	3	8830	1603	3	2825
	504	4	11770	1604	4	3770
	505	5	14715	1605	5	4710
				1606	6	5650
	LUH-506P	6	17660	LUH-1608P	8	7535

Lossnay

POSITIONING THE LOSSNAY ELEMENT AND FANS

Four systems should be considered when using Lossnay together with intake and exhaust fans. For minimum leakage and maximum effective air ventilation, system A or B should be adopted.

System A

In this system, fans are used to draw air through Lossnay element.

The air leakage ratio is approximately 2.5% and 3.4% when the static pressure difference between SA and RA and between EA and OA is 2 in. WG and 4 in. WG respectively. This value is virtually negligible in actual use.

System B

In this system, fans are used to force air through the Lossnay element.

The air leakage ratio is the same as in System A.

System C

Supply air is drawn across the OA and Sa sides while exhaust air is forced through the RA and EA sides of the Lossnay element.

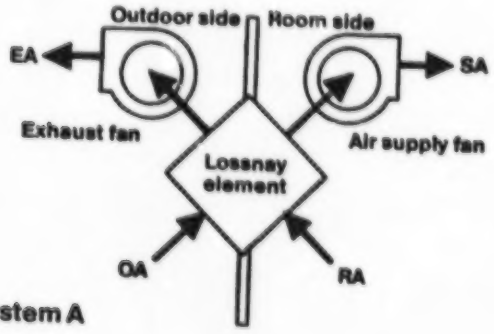
In this system, the air pressure at the supply side (across OA and SA) is negative relative to that at the exhaust side (across RA and EA), which is effectively positive. As a result, air leakage from the exhaust side to the supply side is the greatest of the four systems. The air leakage ratio is 10.5% when the static pressure difference between OA and RA is 2 in. WG and 13.0% when it is 4 in. WG.

This arrangement should therefore be avoided except when more than 10% air leakage is permissible between the exhaust to the supply side.

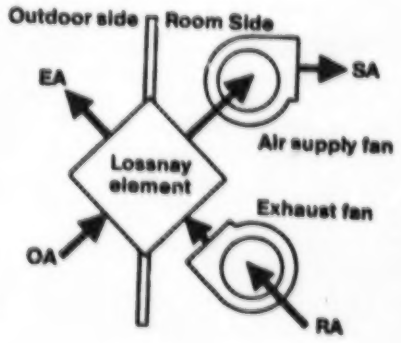
System D

In this system the supply air is forced through the OA and SA sides while exhaust air is drawn across the RA and SA sides of the Lossnay element.

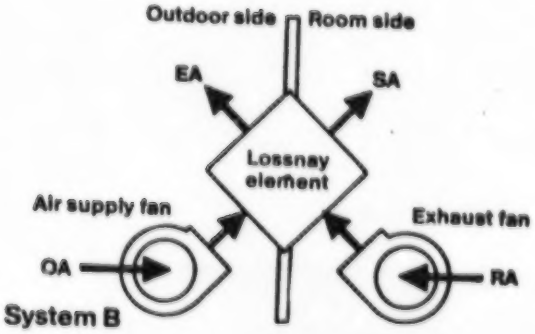
In this case, the positive and negative relation in static pressure mentioned in system C is reversed. Air leakage into the room (from RA side to SA side) is negligible, but air leakage to the outside (from the OA side to the SA side) is equal to that of system C, reducing in the effective volume of ventilating air.



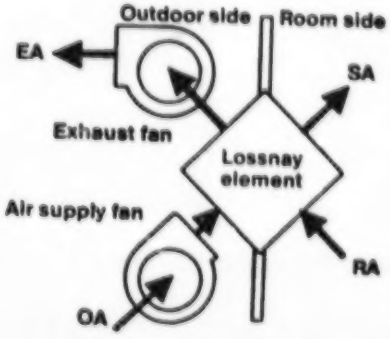
System A



System C



System B



System D

MITSUBISHI ELECTRIC
INDUSTRIAL PRODUCTS

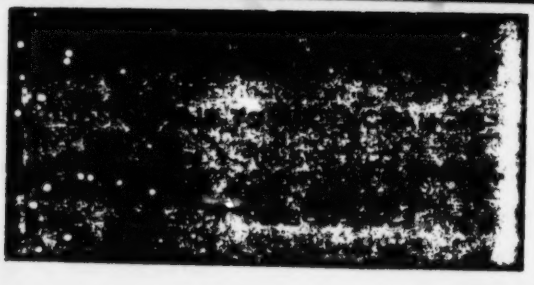
LIMITED WARRANTY

Lossnay Heat Exchanger ("Product") sold by Melco Sales, Inc., ("MSI") are warranted to be free from defects in material and workmanship for a period of twelve (12) months from the date of installation when properly installed, used, and maintained according to MSI's specifications and directions.

Any products which are defective in workmanship or material will be repaired or replaced (excluding labor), at MSI's option, at no charges to MSI's original buyer or buyer's customer. Final determination as to whether a product is actually defective rests with MSI. MSI's obligation hereunder shall be limited solely to repair or replace at MSI's discretion. Such obligation shall be conditioned upon receipt by MSI of written notice of alleged defects or deficiency within thirty (30) days after discovery. Replacement parts for such defective parts shall be shipped FOB destination to MSI's buyer or buyer's customer. Products which MSI consents in writing to have returned shall be shipped freight prepaid, FOB MSI's warehouse in Compton, California. MSI will neither assume responsibility nor accept invoices for unauthorized repairs to products.

THE FOREGOING LIMITED WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY WARRANTY AS TO MECHANABILITY AND FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES SHALL MSI BE LIABLE TO BUYER OR ANY OTHER PERSON FOR ANY SPECIAL OR CONSEQUENTIAL DAMAGES WHETHER BASED UPON LOST GOODWILL, LOST RESALE PROFITS, WORK STOPPAGE, IMPAIRMENT OF OTHER GOODS OR OTHERWISE AND WHETHER ARISING OUT OF BREACH OF WARRANTY, BREACH OF CONTRACT, NEGLIGENCE OR OTHERWISE.

This warranty does not apply to fault performance or deficiencies caused by clogging, improper cleaning, exposure to extremes of heat or cold, lightning, improper voltage supply or any misapplication of the product.



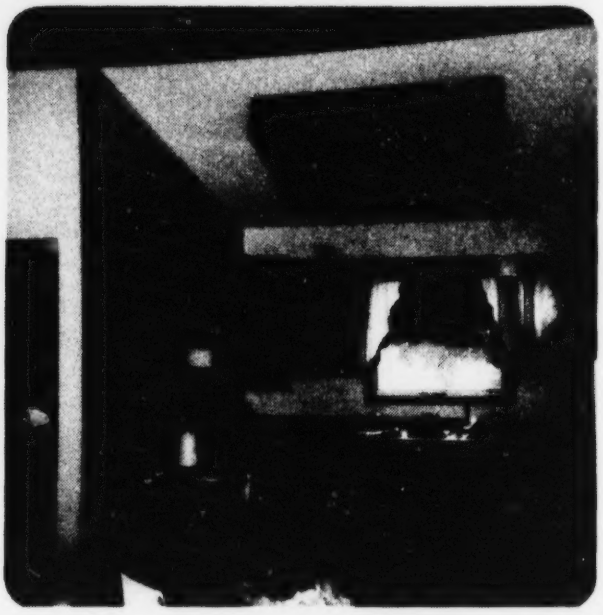
APPENDIX F

PHOTOGRAPHS

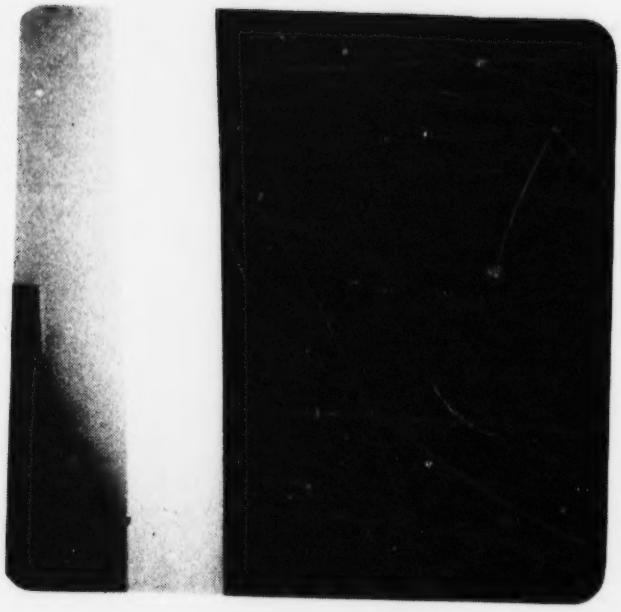
WEST ELEVATION

SOUTH ELEVATION

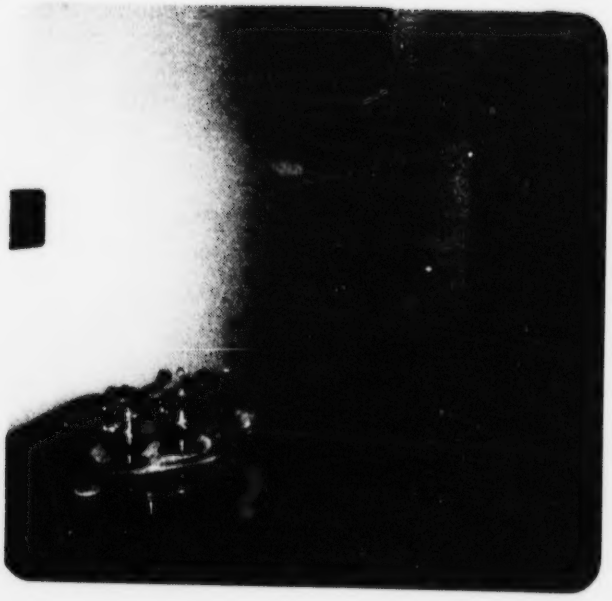
MOCK-UP OF WALL/
ROOF TRUSS SECTION



KITCHEN SHOWING TRIPLE GLAZED,
WINDOW, FLUORESCENT CEILING FIXTURE,
AND HEAT EXCHANGER INTAKE GRILLE

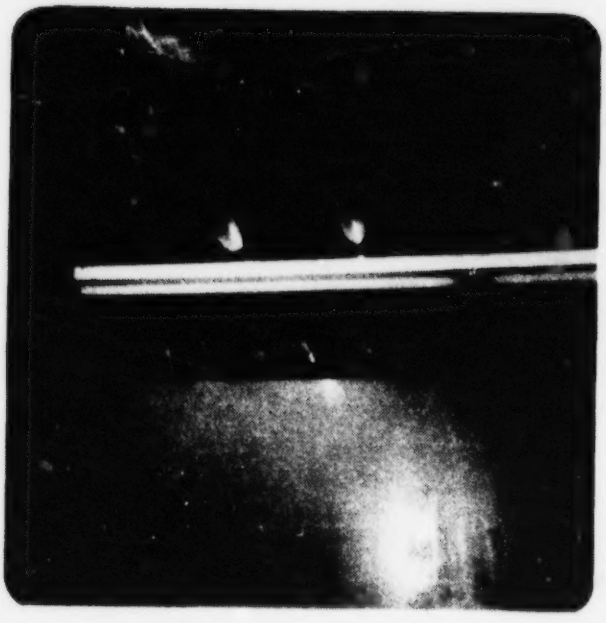


FRONT AIR LOCK ENTRY



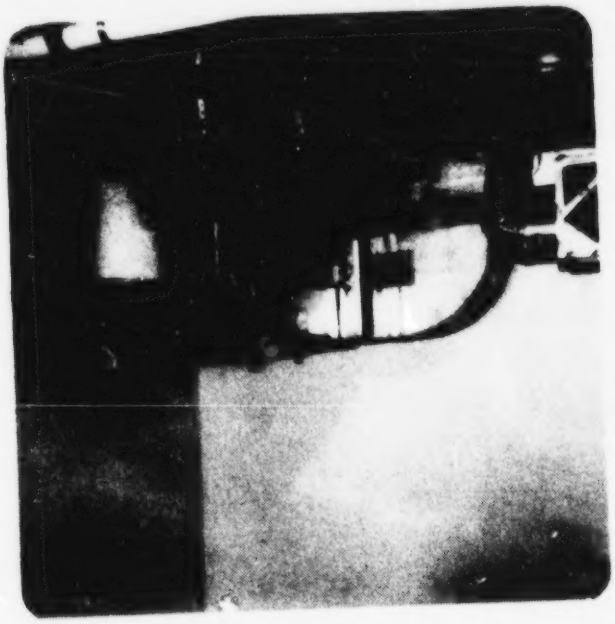
REAR GARAGE ENTRY

PATIO ENTRY

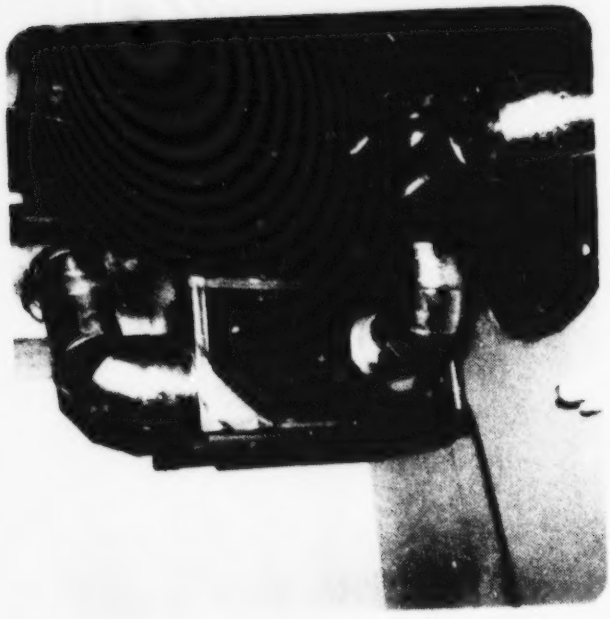


HEADER INSULATION AND
FLUORESCENT BASEMENT LIGHTING

WATER HEATER, CIRCULATING PUMP
AND HOT WATER DUCT HEATER



DUCT BLOWER

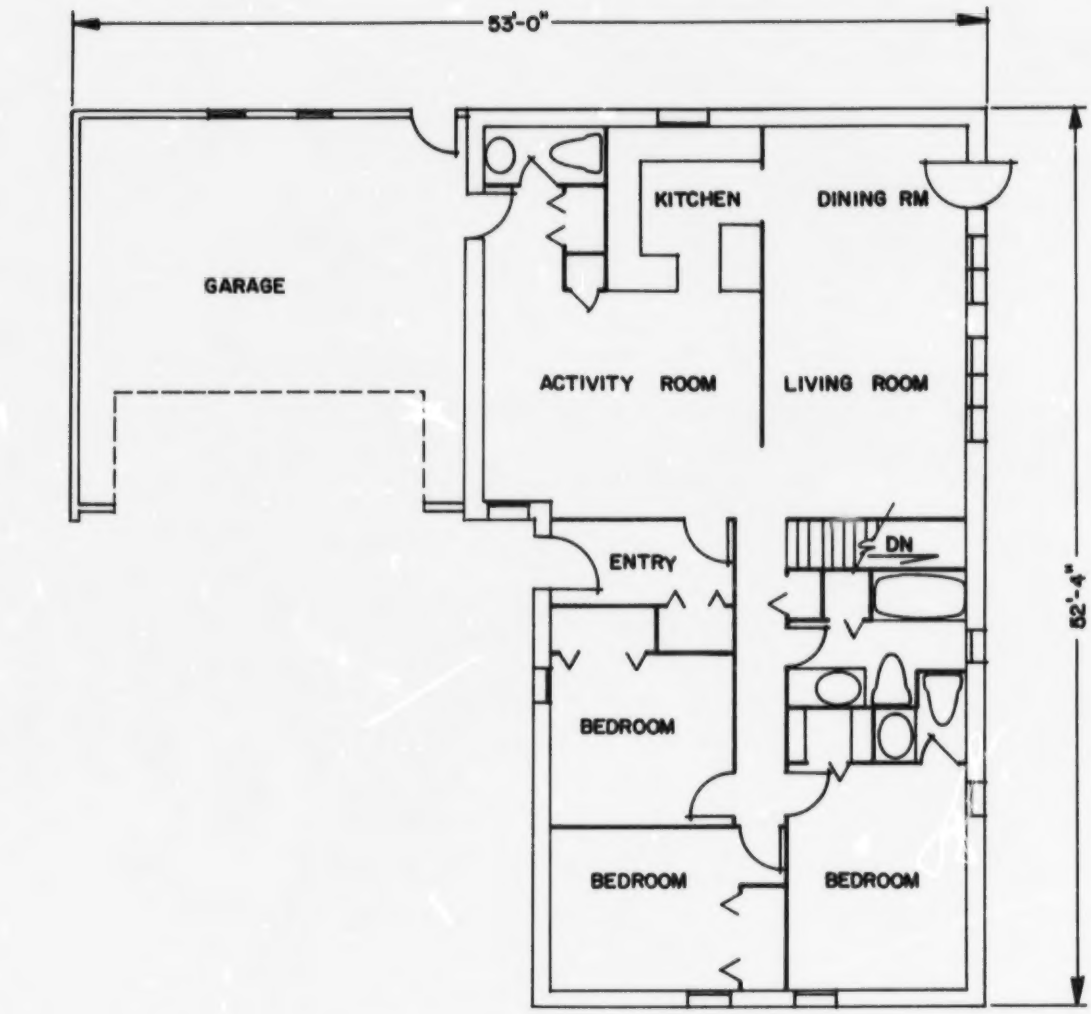


AIR-TO-AIR HEAT EXCHANGER

FRESH AIR INTAKE DUCT
FOR HEAT EXCHANGER

APPENDIX G

FLOOR PLAN



NEUFELD RESIDENCE

Canada

Energy, Mines and Resources Canada
Energie, Mines et Ressources Canada

MANITOBA

DEPARTMENT OF ENERGY AN

MG